# NASA TECH BRIEF



## Biaxial Prestressing of Brittle Materials

Ceramics can be used for many high-temperature industrial applications if their low tensile strengths and poor resistance to impact, vibration, and thermal shock can be overcome. Consequently, research has been carried out on the strengthening of ceramics by metal fibers and whiskers, and by mechanical and thermal prestressing.

Strengthening of chemically consolidated zirconia with tungsten fibers, graphite fibers, sapphire whiskers, and silicon carbide whiskers was investigated experimentally. Addition of silicon carbide whiskers gave the highest increase in strength of zirconia at room and elevated temperatures. Addition of 7.4% by weight silicon carbide whiskers increased the average flexure strength of zirconia at room temperature from 4000 psi to 5620 psi, and at 2000°F, from 165 psi to 1520 psi.

Further improvements in the tensile load-carrying ability of the whisker-strengthed zirconia were obtained by prestressing the matrix with tungsten cables. This prestressing not only increased tensile load-carrying ability, but also imparted some ductility to the brittle ceramic material.

The response of uniaxially prestressed ceramic to thermal shock and thermal cycling was evaluated and found superior to that of non-prestressed material. In addition, a concept of biaxially prestressing cylindrical shells was developed, demonstrated, and evaluated.

A theory was developed for predicting the strength of biaxially prestressed ceramic cylinders subjected to external loading and thermal environment. To verify the theory and to demonstrate the efficiency of these cylinders, a number were designed, fabricated, and tested.

The tests conducted were: internal radial pressure (hoop tensile tests) at room temperature, internal hydrostatic pressure (biaxial tensile tests) at room temperature, internal radial pressure (hoop tensile tests) at 2000°F, and high-velocity ballistic impact tests. Strengths of biaxially prestressed cylinders in hoop tension and biaxial tension at room temperature, and in hoop tension at elevated temperature, were 9350 psi, 10,940 psi, and 4740 psi, respectively. The test data on uniaxially and biaxially prestressed specimens were evaluated and correlated with theory.

### Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference:
NASA-CR-98136 (N69-11473), Development of a System for Biaxial Prestressing Brittle Materials

### Patent status:

No patent action is contemplated by NASA.

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